

Guidelines for Action Effectiveness Research Proposals for FCRPS Offsite Mitigation Habitat Measures

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Introduction

The Action Agencies (Bonneville Power Administration, United States Army Corps of Engineers, and the Bureau of Reclamation) and the National Marine Fisheries Service (NMFS) have developed these proposed guidelines for sponsors and reviewers of action effectiveness research projects. These projects are directed at specific categories of offsite (tributary) mitigation measures identified in the NMFS 2000 Federal Columbia River Power System Biological Opinion (BiOp).

The BiOp Research, Monitoring and Evaluation (RME) program has several tasks as defined by RME Reasonable and Prudent Alternative (RPA) Action Items. Among them is the prescription to develop a multi-component monitoring program to assess the effects of actions called for in the BiOp. A specific mandate for the monitoring program—both for status and effectiveness components of monitoring—is provided in section 9.4.2.8 of the BiOp:

Action 9: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5- year plans for research, monitoring, and evaluation to further develop and to determine the effectiveness of the suite of actions in this RPA.

The BiOp also sets a timetable for the development of a monitoring program, and defines the scope for effectiveness monitoring.

Research, monitoring, and evaluation will provide data for resolving a wide range of uncertainties, including ... establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. Progress on resolving these uncertainties will be a primary consideration in the 1- and 5-year planning process as well as in the 5- and 8-year check-ins. (BiOp page 9-31)

Within this mandate, research on tributary mitigation actions intended to improve salmon survival rates through is specifically identified in RPA 183:

Action 183: Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

In addition, section 9.6.5.3.3 of the BiOp states that

Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points. (FCRPS BiOp page 9-170)

This Effectiveness Research Guidance is designed to assist researchers, habitat managers, and proposal reviewers in developing effectiveness research programs that will satisfy RPA's 9 and 183.

By placing effectiveness monitoring within the context of BiOp RME and explicitly identifying effectiveness monitoring as research, the BiOp implicitly recognizes that tributary habitat actions constitute ecological experiments. Effectiveness research is, therefore, subject to the standards of scientific research. Specifically, data will be collected within an experimental design, results will be evaluated with respect to control or reference data, variability will be described, and decision making will be based on established rules of scientific inference and statistical confidence.

Table 1 identifies the potential distribution of habitat-oriented effectiveness studies, by province, affected ESUs, and project category to satisfy monitoring requests outlined in RPA action 183. Activities for which sponsors will receive funding are:

- 1)Screen Irrigation Diversions
- 2)Barrier Removal
- 3)Sediment Reduction
- 4)Water Quality Improvement
- 5)Nutrient Enhancement
- 6)Restoration of Instream Flows
- 7)Restoration of Riparian Function
- 8)Stream Complexity Restoration

The primary purpose of action effectiveness studies called for under RPA Action 183 is to evaluate tributary habitat actions for the 5-year and 8-year check-ins. This information will also help guide planning efforts by identifying the relative effectiveness of different categories of actions. The primary study response needed to meet the check-in assessment of the BiOp is the change in fish survival at one or more life stages associated with the category of action. The off-site mitigation actions are expected to affect both physical or environmental indicators and salmonid survival or condition at any of several life stages. Because habitat actions may require time beyond the BiOp planning horizons to manifest fish survival effects, we also need to establish cause-and-effect relationships between tributary actions and physical/environmental effects that may be detectable sooner than survival changes. This information will be integrated with status monitoring, other types of action effectiveness research, and critical uncertainties research as part of a broader comprehensive Research, Monitoring and Evaluation (RME) Program that is called for by the BiOp, the Federal Caucus Basinwide Strategy, and the Columbia River Basin Fish and Wildlife Program, and outlined in the Action Agencies Implementation Plans. An overview of a proposed framework for a comprehensive RME plan follows. It is discussed in more detail in "RM&E Framework for Requirements of the FCRPS BiOp and the Federal Basinwide Salmon Recovery Strategy" (future website).

Action Effectiveness Research as part of a comprehensive RME program.

As described above, the BiOp describes a comprehensive RME program. This guidance document addresses only one component of that comprehensive program. The following RME framework is based on the monitoring requirements presented in the NMFS BiOp and the Basinwide Strategy, and it indicates the manner in which the program described here relates to the larger RME program:

1. **Status Monitoring** – abundance, trend, or condition of fish populations and key environmental attributes for performance assessments.
 - Ecosystem
 - Tributary
 - Hydro-corridor
 - Estuary/ocean
2. **Action Effectiveness Research and Monitoring** - expected benefits of hydro and off-site mitigation actions.
 - Ecosystem
 - Tributary
 - Project Specific Effects
 - Watershed Program Effects
 - Hydro-corridor
 - Estuary/ocean
3. **Critical Uncertainty Research** - information needed to reduce key uncertainties in assessments of fish survival requirements.
 - BiOp Assessment Critical Uncertainties (i.e., “D”, Extra Mortality, Supplementation Reproductive Success)
 - Basic Research for BiOp and FWP
4. **Implementation Monitoring** - information for mitigation reporting and auditing.
 - Project cost/completion tracking
 - Project physical results tracking
5. **Data Management System** - support system for data archiving and access.
 - Development
 - Maintenance

Under the status and action effectiveness research categories, two classes of indicators are tracked, those describing the performance of fish populations (abundance, survival, condition), and those describing the environmental condition of the habitat.

Intended Audience for this Document

- Managers and project sponsors who are implementing new monitoring programs as components of ongoing recovery actions.
- Managers who are designing and implementing new recovery actions and who need to design and implement a monitoring program to assess that recovery action.

These guidelines for Action Effectiveness Research will offer guidance so that as new recovery actions are conceived and proposed, monitoring may be developed as an integral component of the action design, although many actions will not be monitored for biological effects. However, in many cases offsite mitigation actions are already being funded. As such, the strategy for monitoring some of these recovery actions will be to design *post hoc* an effectiveness research plan that can be applied to an on-going action. This is challenging because recovery actions are rarely designed to answer RME questions. In these cases it will be particularly challenging to design adequate research programs. In some cases it may be necessary to work with project sponsors to modify recovery actions to meet the demands of RPA 9 and 183. Potential project sponsors should be aware that willingness to work with the AA in the design of monitoring will be a component in prioritizing projects.

- Those reviewing proposals for effectiveness research.

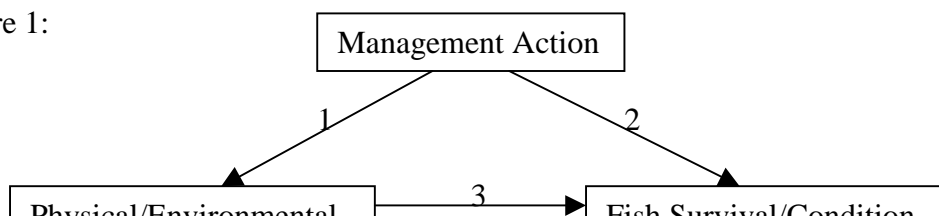
As project sponsors generate proposals to fund their programs, the proposals will be evaluated. It is only fair that the proposals be evaluated on the basis of the design criteria and expectations of the Action Agencies and NMFS. Thus, those tasked with the review of the proposals need to be aware of the details of those standards.

Scope and Strategy for Action Effectiveness Research

This document presents guidelines for Action Effectiveness Research (AER) for Tributary - Project Specific Effects only. Some of the principles are similar to effectiveness research conducted in the other geographic zones (e.g., estuary) or indeed other types of monitoring and research. Assessing the combined effects of a suite of different projects within a watershed is another type of Tributary Action Effectiveness Research that is not specifically covered by these guidelines, although most of the principles and methods apply equally well. Therefore, the boundaries of the AER program should be recognized clearly at the outset.

Since management actions are manipulations of the environment they are *de facto* ecological experiments, although they are rarely designed as such. Being experimental, their outcomes must be evaluated within a scientific framework that includes the framing of hypothesis, identification of references and/or controls, and the recognition of the role of uncertainty in decision-making. Action effectiveness experiments will test hypotheses regarding the effects of management actions on physical/environmental indicators and/or salmonid life-stage survival(s) or condition (Process 1 and/or 2 in Figure 1). Information from these studies may also identify the relationships between the physical/environmental conditions and the salmonid life-stage survival or condition (Process 3).

Figure 1:



The objective is to assess the effects of management actions on fish performance (survival and condition) and habitat condition. The design strategy has three parts:

1. Identify the actions that are implemented;
2. Collect the data on a variety of indicators;
3. Document the presence or absence of anticipated effects of actions on fish and environmental responses (pathways 1 & 2 in Fig. 1)

Demonstrating the effectiveness of management actions requires well-designed research experiments, with controls and replication. Status or trend monitoring will not suffice in satisfying the effectiveness research needs identified in the BiOp. This is because we must balance local needs with regional needs:

1) Evaluate the local effects of individual recovery actions (i.e., determine the effect of habitat actions on life stage survival).

2) Evaluate generality of the results (i.e., does the effects of actions differ among regions, subbasins, etc.).

The ultimate goal is to assemble a “tool-box” of information on tributary habitat actions so that future actions are effective and efficient.

The region has invested substantial time and resources on habitat enhancement activities, but the type of monitoring identified in the BiOp has been very limited. Projects are routinely monitored for completion (implementation monitoring), but monitoring the effects of enhancement projects on the local environment (e.g., did riparian planting decrease stream temperature?) has rarely been undertaken as part of the Fish and Wildlife Program. Monitoring to detect the effects of mainstem actions on survival is quite common (e.g., the USACE AFEP program), but adequately designed, systematic research to detect the effects of tributary habitat projects on salmonid survival has rarely been done. The required monitoring program will be a large-scale effort, although it clearly will be impossible to monitor all tributary actions. For each potential action/ESU combination identified in Table 1, numerous treatment and control sites probably will be required to achieve adequate statistical power.

Effects of similar actions may well differ across ecological, geological, and geomorphic strata. Therefore, we offer a system of stratification that incorporates factors that influence physical/environmental stream features (Table 2). By recording these stratification variables,

researchers will be able to assess differential responses of indicator variables to management actions within different classes of streams and watersheds.

Effectiveness research projects will be required to monitor a prescribed set of physical/environmental and biological indicator variables specific to an action category. Comparisons across classes of actions will be facilitated by consistent measurement of indicators. We provide these under the assumption that they will be affected by the management actions. The presence of these indicators on a list is not an assertion of an established relationship between specific management actions and changes in these variables. Elucidation of these relationships is a key objective of the research.

Table 3 identifies the physical/environmental indicator variables (I) that should be measured for each type of action. The types of actions are listed across the top row. Below each of these are examples of the expected consequences of the actions. In some cases the actions are narrowly focused in their effects (e.g., screening fish diversion channels). In other cases, however, a recovery action may have more diffuse environmental effects. Road closures, for example, may affect both sedimentation rates and riparian habitat quality.

Some of the variables in Table 3 are labeled as classification variables (C), because although they are unlikely to change as a consequence of the specific action, they provide information that may allow stratification *post hoc*. It is possible that certain recovery actions will work under some circumstances but not under others. These classification variables may allow potential differences to be evaluated in order to find what characteristics of the environment were associated with success or failure.

In the case of those indicators that are neither classification variables nor indicator variables for a specific class of action, the variables are listed as optional (O). Collecting this type of data is not required, but may be collected if the proposal sponsor is prepared and willing to do so. The benefit of collecting these data is that they can contribute to the status monitoring needs of a larger RME program, and efficiencies in monitoring protocols can be increased. The responsibility for taking that extra step is left up to those planning monitoring for individual projects.

In Table 4, we summarize some available methods for estimating salmonid survival. All methods identified in Table 4 have potential problems, and researchers should carefully consider these when designing effectiveness experiments. PIT tags, for example, have been used for over a decade to estimate juvenile survival in the Snake River Basin (e.g., Achord et al. 1997; Skalski et al. 1998; Paulsen and Fisher 2001). However, PIT tags (and other mark-recapture estimates, see Seber 1982; Thompson et al. 1998) require at least two recapture points after initial tagging to estimate survival: an upstream site (for the survival estimate proper) and a second site further downstream to estimate detection rates at the upstream location. This will limit areas where they can be applied, even with installation of additional smolt and adult detectors at mainstem dams. Electrofishing and snorkeling estimates of abundance have been used widely (e.g., Roni and Fayram 2000; Hillman and Miller 2002), but these too have potential drawbacks (e.g., Thompson et al. 1998; Thompson and Lee 2000), since assumptions regarding the detectability of fish are often difficult to verify in practice. Estimates of parr or smolt abundance via mark-recapture

(e.g., Skalski 1996) have well-known statistical properties, but require high parr-to-adult survival rates for precise estimates. In addition, juveniles of many populations may be very mobile, making it difficult to be certain that marked individuals are representative of the population of interest. Estimates of adult pre-spawning survival depend on high, known detectability or recapture rates, which may be difficult for some species (e.g., steelhead) spawning during high flows. In addition, weirs – often used to capture and enumerate adults – may fail to capture the entire population during high flows or because of movement of large woody debris past the weir.

The effectiveness studies and indicator variables identified above are expected to meet the primary objects of RPA 183. However, a limited set of studies designed to “intensively” investigate the underlying mechanistic web of relationships between actions and the environmental or survival responses of salmonids will also be useful. This type of study would consist of more detailed ecological and ecosystem experiments to attempt to understand the relationships between actions, physical/environmental conditions, and salmonid survival/condition (i.e., more detailed, finer level steps in processes 1, 2, and 3 identified in Figure 1). Hypotheses tested within this intensive monitoring approach address the ecological mechanisms behind the effects of management actions directly, rather than implicitly. For purposes of further guidance and discussion, we will refer to this more detailed study design as the **intensive monitoring option**. An intensive monitoring option would require the same design elements as the less detailed studies, with more detailed intensive monitoring as an addition. Researchers proposing an intensive monitoring option should clearly state their intent to perform research at this level.

Some general features are common to both the “basic” monitoring design and the “intensive” monitoring option, and they are hierarchical in nature. For example, acquisition of monitoring data will require choices that balance data collection efforts with cost. This hierarchical design scheme is expressed in Figure 2. The figure shows how experimental design choices, suggested by answers to the questions asked at each level contribute to the accuracy and precision of the final results. If effectiveness research succeeds in illuminating the relationships between recovery actions and biological response, it will do so because it was designed to maximize statistical power by reducing variance at each level in the hierarchy.

For specific guidance in planning of monitoring protocols and protocols for assaying habitat indicators, the reader is advised to consult Hillman and Giorgi (2002), Johnson et al. (2001), Cohen (1988), and Kraemer and Thiemann (1987). Thomas and Krebs (1997) give additional information on tools that are available to help evaluate statistical power.

Combining Results from Different Studies

One objective of the Action Agencies is that individual studies of the same action type (e.g., riparian improvement) can be combined to yield information about the general effects of that type of action on environmental conditions and salmonid survival. To facilitate this goal, all monitoring projects for a given class of actions should attempt to measure the same subset of environmental and biological indicators listed in Tables 2-5. In addition, those measurements need to be made in a manner that allows direct statistical comparison across studies in different

ecoregions and landscape types. Once again, including the classification variables into all of the projects will facilitate these *post hoc* comparisons.

For example, increases in riparian cover may yield increases in parr-to-smolt survival. Assume that riparian enhancement activities are undertaken in five subbasins, each with suitable local controls. After the studies are complete, it would be desirable to be able to make direct comparisons among the five studies, to see how survival changes vary among the different areas. If survival has been estimated using a protocol that is similar, or at least directly comparable, across all five areas, this should be straight-forward. If, on the other hand, one area uses PIT tags, another uses spawner-recruit relationships, and a third uses parr and smolt abundance surveys, such a comparison will become nearly impossible. If measurement methods differ widely, it will be very difficult to determine if differences in estimated survival rate changes are real or are a function of the methods used.

Use of a set of standardized protocols will satisfy these requirements. Application of a standard set of indicators and measurement methods will be limited by differences in local conditions. Therefore, while the list of indicators to be measured is prescribed, the protocols are not, subject to the condition that whatever the protocol used, it be

- 1) completely documented and
- 2) include estimates of the sample size, mean, and variance for each indicator.

More detailed information and a statistically-based rationale for standards to combine results of multiple studies can be found in Gurevitch and Hedges (2001).

Guidelines for Effectiveness Research Proposals

The guidelines below apply to all monitoring proposals. An example of guidance for the intensive monitoring option follows this section. Technical terms (e.g., sampling frame) in the guidelines are fully explained in Hillman and Giorgi (2002), as is the rationale for the guidelines. General considerations—implied by the guidelines—in designing actions and attendant monitoring as experiments consist of the following:

- Manipulations of habitat constitute ecological experiments, and as such must be designed in the context of testable hypotheses. Therefore, all monitoring programs for effectiveness projects will have hypotheses and controls. In almost all cases, multiple treatment and control sites will be required to obtain results within a reasonable time frame. Control sites are crucial for illuminating casual links between management actions and environmental or survival effects. They should be as similar as possible to treatment sites, with thorough documentation of that assessment.
- Because the program will measure environmental and biological responses to recovery actions, the performance of the effectiveness research program must be specified. As a first cut, we offer the same “preliminary” performance targets for statistical power that have been developed in the Oregon Monitoring Plan. Specifically, effectiveness monitoring projects should be designed to provide: Type I error rate of 0.2, Power (1-Type II error rate) of 0.80, and the ability to detect a 2% change in indicator values per

year, for a net change of 17% after 8 years. Larsen et al. (2001) suggest that these standards are achievable for a variety of physical habitat indicators. However, it appears at present that achieving these goals may be very challenging for some biological indicators. Therefore, we also recommend that proposals include power analyses for a wide but plausible range of effect sizes (including the single point estimate of 2%). Pilot studies may be required to obtain plausible estimates of effect size, so targets will be refined as the effectiveness research program matures. Indeed, it will be a continuing task for the AA and NMFS to develop performance standards for effectiveness research.

As pointed out by the ISRP, whatever standards are adopted by the regional effectiveness monitoring program, it is unlikely that individual habitat projects – even with carefully pared controls - will be powerful enough to satisfy them. Probably, individual projects will have to be coordinated so data from each project can be pooled to increase overall statistical power. As mentioned above, this places substantial demands on rigorous replication of experimental design across projects. Monitoring protocols must be compatible, and resulting data must be freely shared. There is little historical precedent for this level of regional coordination.

- Similar to effect size, temporal and spatial variation in survival rates or condition, sampling variability, and measurement error will often be unknown at the outset of the experiment, although existing information should obviously be used where possible. Valuable data on variability in physical/environmental indicators is provided in Kaufmann et al. (1999). Again, for planning purposes power analysis should encompass a wide range of plausible values of variance, and pilot studies may be needed.
- If estimates of effect size and temporal and spatial variation are known when proposals are being written, then sample sizes, sampling effort, and duration of the experiment can be calculated. Each implementation is expected to place different demands on monitoring effort. In each case, the basis for the design will be documented to allow evaluation of proposals, and subsequent comparison of results across projects.
- Action effectiveness projects will monitor both physical/environmental and biological indicators. Habitat alterations can affect salmonids in three ways: by increasing potential habitat that can be occupied; by improving the quality of currently occupied habitat; or both. In cases where habitat area increases, it is important to measure utilization of newly available habitat. Therefore, in addition to the suite of appropriate physical, environmental, and biological indicators, effectiveness research monitoring on these projects will include estimates of listed salmonid abundance at the appropriate life stage(s). For projects changing habitat quality, monitoring will measure changes in life stage survival rates.

What follows is a checklist of items that should be addressed when developing effectiveness research proposals.

Overarching Issues:

1. Describe the physical/environmental problem to be improved or corrected by the management action(s) being monitored.

2. Describe current environmental conditions at the project site.
3. Describe factors contributing to current conditions (e.g., road crossings causing siltation).
4. Describe the management action(s) (treatment) to be undertaken to improve existing conditions.
5. Describe the goal or purpose of the management action.
6. Describe hypotheses to be tested.
7. Describe the independent variables in the study.

Experimental Design:

1. Describe the statistical design to be used (e.g., before-after, BACI).
2. Describe how treatments (management actions) and controls will be assigned to sampling units (e.g., random assignment).
3. Show whether or not the study will include “true” replicates or subsamples.
4. Describe how temporal and spatial controls will be used and how many of each type will be sampled.
5. Describe the independence of treatment and control sites (e.g., are control sites completely unaffected by treatments/management actions?).
6. Describe how variables will be co-varied in the experiment.
7. Describe potential threats to internal and external validity, and how these threats will be addressed.
8. If a pilot test of the experiment is needed, explain and describe same.
9. Describe descriptive and inferential statistics to be used, and how precision of statistical estimates will be calculated.

Sampling Design

1. Describe the statistical population (e.g., cobble embeddedness measured in 100 m reaches) to be sampled.
2. Define and describe sampling units (e.g., 100-m long sampling sites).
3. Describe the number of sampling units – both treatment and control sites - that make up the sampling frame.
4. Describe how sampling units will be selected (e.g., random, stratified, systematic, etc.).
5. Define “practical significance” (e.g., environmental or survival effects of the actions) for the study.
6. Describe how effect size(s) (environmental and survival effects) will be detected.
7. Describe the variability or estimated variability of the statistical population(s).
8. Define the Type I and II errors to be used in statistical tests (we recommend no less than 0.8 power).

Field Measurements

1. Describe indicator (dependent) variables (environmental and biological) to be measured.
2. Describe methods and instruments to be used to measure the indicators.
3. Describe the precision of the measuring instrument(s).

4. Describe the possible effects of measuring instruments on the sampling unit (e.g., core sampling for sediment may affect local sediment conditions). If such effects are expected, how will the study deal with this.
5. Describe steps to be taken to minimize systematic errors.
6. Describe QA/QC plan, if any.
7. Describe sampling frequency for field measurements.

Results:

1. Explain how the results of this study will yield information relevant to management decisions.
2. Describe how the study will provide useful results for the 5-year and 8-year check-in assessments identified in the Biological Opinion (NMFS 2000) specific to benefits or expected benefits of off-site mitigation actions.

Intensive Monitoring Option Guidance

Currently, we have insufficient information to make quantitative performance predictions for most classes of recovery actions. This includes those categories of actions listed in Table 3. In the conceptual framework described by Figure 1, above, recovery actions are implemented and the habitat or population responses are monitored. The data collected within that framework of effectiveness research forms the basis of a cause-and-effect analysis between actions and responses, but does not address underlying mechanisms. This allows quantitative predictions to be made for recovery action performance as long as the circumstances are sufficiently similar. Such quantitative predictions can be applied to other, less similar regions, but their predictive power is greatly reduced. To create an understanding that is sufficient to increase predictive power requires monitoring that is designed to illuminate underlying mechanism of response. Therefore, in addition to the effectiveness research program outlined above, proposals will be accepted for monitoring of recovery actions in the **Intensive Monitoring** option.

Intensive monitoring is a vehicle for illuminating the mechanistic relationships between recovery actions and population responses. Intensive monitoring is an alternative, additional monitoring effort to the effectiveness research described above. The intensive monitoring option is designed to test hypotheses that are more explicitly defined to illuminate ecological mechanisms for the observed biological responses to recovery actions. Intensive monitoring projects will be designed as complete field ecological experiments with the following characteristics:

- Proposals for the intensive monitoring option are anticipated to be similar to proposals for national research funding standards and will be evaluated as such. These proposals will be judged on the hypothesis or scientific question posed, justification of spatial and temporal scale, as well as documentation and justification of the experimental and analytical approach.
- One objective of the intensive monitoring option is to validate the results of the general effectiveness research option. Therefore, intensive monitoring projects will monitor the

same indicators described above and will achieve all of the guidelines described for effectiveness above. To explore mechanisms behind survival changes, intensive projects will also monitor other phenomena, depending on the hypotheses under investigation.

The principal difference between these monitoring options is the mechanistic detail of the tested hypotheses and the consequent increase in investment of resources to evaluate those more detailed hypotheses. As such, we can not specify the specific hypotheses that will be tested, or the investment of resources within each intensive monitoring project. However, in an effort to provide guidance for potential proposals in the intensive monitoring option, example questions are provided that apply to the riparian improvement recovery actions. These questions indicate the level of detail and the ecological framework that is anticipated for intensive projects.

Riparian/Habitat Improvement

Fish Ecology Questions:

- What is the fish response to the action?
 - What species and life stages utilize this habitat?
 - What is the change in salmonid egg-fry survival with the action?
 - What is the change in salmonid fry-smolt survival with the action?
 - Are there changes in juvenile salmonid density with the action?
 - Which life-history change shows the largest response to the action?
 - Are there changes in non-salmonid densities with the action?

Habitat Ecology Questions:

- What was the historic riparian composition of the site?
 - What is the soil site potential?
- Did the riparian restoration project attempt to restore historic species compositions? If not, why?
- How does the current species (salmonid as well as others – including other invertebrate and vertebrate species) assemblage compare with historic structure or potential species assemblage?
- What are the overall survival and individual tree and shrub species survival at the site relative to a control or before restoration?
- What are the overall growth rate and individual tree and shrub species growth rate at the site relative to a control or before restoration?
- Did riparian plantings take into consideration evapo-transpiration rates?
- What are the normal successional riparian processes for the site and did plantings reflect a strategy developed within the context of riparian succession?
- Is there an attempt to create a diverse community, or is the strategy to increase biomass with a few fast growing species?
- What is the projected, and subsequently realized level of herbivory on riparian plantings? And what designs exist within the action to control, or account for herbivory? Do bank morphology and stability change?
- Does substrate quality change?
- Do sedimentation rates change?

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Table 1. Distribution of habitat-oriented effectiveness research studies, by province, affected ESUs, project category and examples, to satisfy monitoring requests outlined in Action 183 of the 2000 FCRPS Biological Opinion. Snake River fall chinook and sockeye are not included in this table, because of the minimal affect of tributary habitat improvements anticipated for the ESUs.

Province(s)	Project Category	Examples of projects	ESUs affected
Lower Columbia & Columbia Estuary	Restore riparian function	Reduce land-use activities in riparian areas	Chum LC Steelhead UW Chinook UW Steelhead
	Blockage removal	Improve passage at culverts and diversions	Chum LC Chinook LC Steelhead UW Chinook UW Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	Chum LC Chinook LC Steelhead
	Improve water quality	Reduce sources of pollution	UW Chinook UW Steelhead
Columbia Plateau and Columbia Gorge	Irrigation screens	Add fish exclusion screens	MC Steelhead
	Restore riparian function	Reduce land-use activities in riparian areas	MC Steelhead
	Blockage removal	Improve passage at culverts and diversions	MC Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	MC Steelhead
	Improve water quality	Reduce sources of pollution	MC Steelhead
	Nutrient enrichment	Add fertilizer or carcasses to streams	MC Steelhead
Columbia Cascade	Restore instream flows	Acquisition of water rights	UC Spring Chinook UC Steelhead
	Restore riparian function	Reduce land-use activities in riparian areas	UC Spring Chinook UC Steelhead
	Blockage removal	Improve passage at culverts and diversions	UC Spring Chinook UC Steelhead
	Irrigation screens	Add fish exclusion screens	UC Spring Chinook UC Steelhead
Mountain Snake and Blue Mountain	Irrigation screens	Add fish exclusion screens	SRSS Chinook SR Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	SRSS Chinook SR Steelhead
	Restore instream flows	Acquisition of water rights	SRSS Chinook SR Steelhead
	Blockage removal	Improve passage at culverts and diversions	SRSS Chinook SR Steelhead
	Nutrient enrichment	Add fertilizer or carcasses to streams	SRSS Chinook SR Steelhead

Table 2. List of stratification variables that will be measured as part of effectiveness research within tributary habitat in the Columbia Basin. The stratification variables are nested according to spatial scale and their general characteristics. Recommended sampling protocols are also included (Table is from Hillman and Giorgi 2002).

Spatial scale	General characteristics	Stratification variable	Recommended protocol
Regional setting	Ecoregion	Bailey classification	Bain and Stevenson (1999)
		Omernik classification	Bain and Stevenson (1999)
	Physiography	Province	Bain and Stevenson (1999)
	Geology	Geologic districts	Overton et al. (1997)
Drainage basin	Geomorphic features	Basin area	Bain and Stevenson (1999)
		Basin relief	Bain and Stevenson (1999)
		Drainage density	Bain and Stevenson (1999)
Valley segment	Valley characteristics	Valley bottom type	Cupp (1989); Naiman et al. (1992)
		Valley bottom width	Naiman et al. (1992)
		Valley bottom gradient	Naiman et al. (1992)
		Valley containment	Bisson and Montgomery (1996)
Channel segment	Channel characteristics	Elevation	Overton et al. (1997)
		Channel type (Rosgen)	Rosgen (1996)
		Bed-form type	Bisson and Montgomery (1996)
		Channel gradient	Overton et al. (1997)
	Riparian vegetation	Riparian cover group	Overton et al. (1997)
		Riparian community type	Overton et al. (1997)

Table 3. List of physical/environmental habitat indicators that should be incorporated into effectiveness research plans for each type of management action identified in the 2000 FCRPS Biological Opinion. Under each type of management action, the 29 variables are identified as classification (C), indicator (I), or optional (O) variables. Certain indicators may respond to certain management actions but not to other actions. Therefore, indicators may have different designations in different action categories. See Hillman and Giorgi (2002) for definitions of indicators.

Physical/environmental indicators	Management actions identified in 2000 FCRPS Biological Opinion							
	Screen Irrigation Diversions	Remove Blockage	Reduce Sediment	Improve water quality	Enhance Nutrients	Restore instream flows	Restore riparian function	Restore stream complexity
MDMT	O	O	O	I	O	I	I	O
MWMT	C	C	C	I	C	I	I	C
Turbidity	C	C	I	I	I	I	I	I
Depth fines	C	C	I	C	C	C	C	C
Metals/pollutants	O	O	I	I	I	O	O	O
pH	O	O	O	I	I	O	O	O
DO	C	C	C	I	I	C	C	C
Nitrogen	C	C	C	I	I	C	C	C
Phosphorus	O	O	O	I	I	O	O	O
Road crossings (culverts)	C	I	C	C	C	C	C	C
No. of diversion dams	I	I	I	C	C	C	C	C
Fishways	O	I	O	O	O	O	O	O
Dominant substrate	C	C	I	C	C	C	C	I
Embeddedness	O	O	I	O	O	O	O	I
LWD	C	C	C	C	C	C	C	I
Pool frequency	C	C	I	C	C	I	C	I
Pool quality	C	C	I	C	C	I	I	I
Off-channel habitat	C	C	C	C	C	I	I	I
Width/depth	O	O	I	O	O	I	I	I
Wetted width	C	C	C	C	C	C	C	C
Bankful width	C	C	C	C	C	C	C	C
Bank stability	O	O	I	I	O	I	I	I
Change in peak Q	I	I	I	I	O	I	O	I
Change in base Q	I	I	I	I	O	I	O	I
Change in Q timing	I	I	I	I	O	I	O	O
Road density	O	O	I	I	O	O	I	I
Riparian-road index	O	O	I	C	O	O	I	C
Equivalent clearcut	I	O	I	I	C	I	I	O
Percent veg altered	I	O	I	I	I	O	I	I

Table 4. Salmonid life-stage survival/condition indicators and possible methods of sampling and detection.

Life stage	Possible methods	Cautionary notes	References
Survival Rates			
Pre-spawning	1. Mark (visual tag at weir) and “recapture” (sightings during redd counts) of returning spawners. 2. Mark (PIT tag at weir) and recapture (detections via instream detectors during redd counts) of returning spawners.	Both methods will be difficult for steelhead, which spawn during high flow.	Jacobs et al. (2001)
Egg-fry	1. Estimate egg production via fry emergence traps placed over redds. 2. Estimate egg production indirectly as the product of redd counts and assumed fecundity.	Redd caps are inefficient and may increase fine sediment deposition within the redds. Error in redd counts and assumed fecundity (error in assuming hatchery fecundity = wild fecundity).	Hartman and Scrivener (1990)
Fry-parr	1. Estimate population size of fry and parr during stream surveys.	The precision of fry and parr estimates are not well established and likely vary between sites, years, and sampling methods.	Nemeth et al. (1996) Thompson and Lee (2000)
Egg-parr	1. Estimate egg production and parr abundance with methods described above.	Cautions described above of estimating egg production and parr abundance apply here.	Hillman and Miller (2002)
Spawner-parr	1. PIT tag parr and check adults for tags on return to spawning grounds (modified Lincoln-Peterson estimate).	Requires weir with high detection rate to detect adults.	Skalski (1996)
Parr-smolt	1. PIT tag or dye mark parr in rearing areas and recapture at downstream dams or traps.		Paulsen and Fisher (2001)
Spawner-recruit	1. Count and age spawners and use these data to estimate recruitment.	Estimates will not be specific to life-stage. Lag between spawning and subsequent recruitment may be outside BIOP planning horizons.	Beamesderfer et al. (1997)
Condition/Size			
Parr condition	1. Capture and subsequent measurement of length and weight		
Smolt condition	1. Capture and subsequent measurement of length and weight		

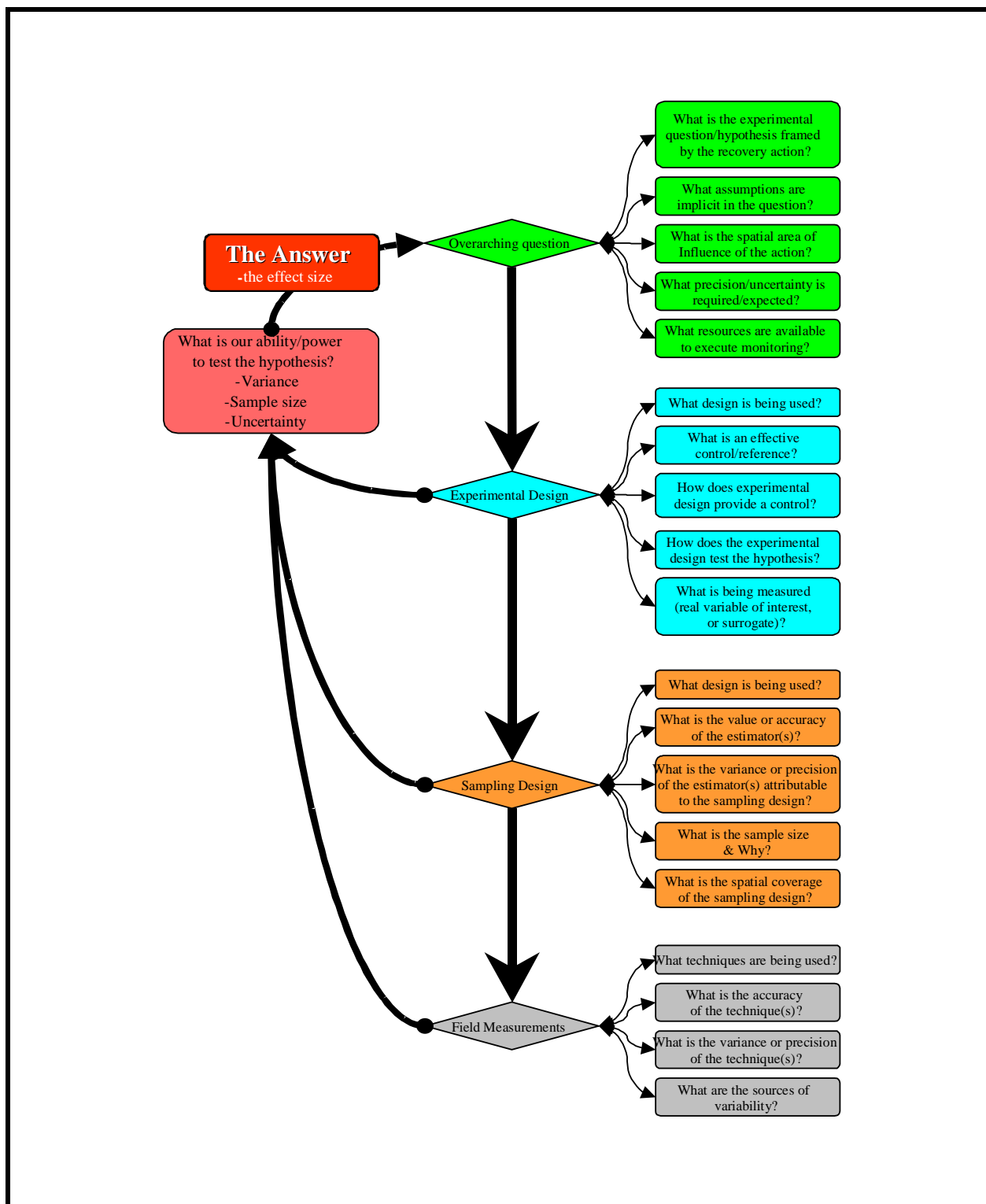


Figure 2. Examples of questions to guide proposals for effectiveness research. Note that specific guidelines are contained in design section of this memo.